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TITLE: SINTERED TOOL STEEL AND PRODUCTION METHOD THEREFOR

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ABSTRACT:

PROBLEM TO BE SOLVED: To provide a sintered tool steel which has a hyperfine grain structure, has high strength and excellent wear resistance and workability, and is suitable as a structural member, or the like, in particular, for an extremely small member and an extremely thin member.

SOLUTION: The sintered tool steel has an alloy component having a composition containing, by weight, 0.8 to 2.5% C, 3 to 8% Cr, 1 to 10% Mo, 1 to 20% W, 1 to 7% V, ≤15% Co, ≤1% Si and ≤1% Mn, and in which the W equivalent (2Mo+W) simultaneously satisfies 15 to 30%, and the balance Fe with inevitable impurities. Also, the maximum grain size of carbides in the alloy is ≤0.6 μm, and the average grain size of austenitic crystals is ≤2.0 μm.

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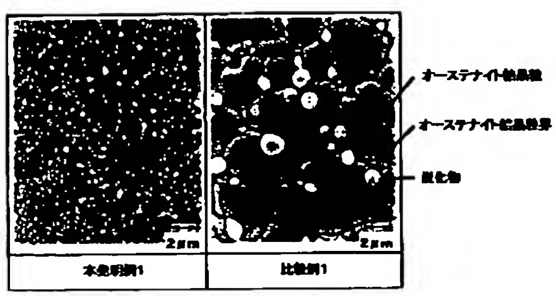
(54)【発明の名称】　焼結工具鋼及びその製造方法

(57)【要約】

【課題】　超微細粒組織を有し高強度で耐摩耗性と加工性に優れた、工具、構造部材等として特に極小および極薄部材に好適な焼結工具鋼を提供する。

【解決手段】　合金成分が重量%でＣを０．８～２．５%、Ｃｒを３～８%、Ｍｏを１～１０%、Ｗを１～２０%、Ｖを１～７%、Ｃｏを１５%以下、Ｓｉを１%以下、Ｍｎを１%以下含有すると同時にＷ当量（２Ｍｏ＋Ｗ）が１５～３０%であり、残部がＦｅと不可避不純物から成る組成を有し、且つ合金中の炭化物最大粒子径が０．６μm以下及びオーステナイト結晶の平均粒子径が２．０μm以下である焼結工具鋼とする。



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【特許請求の範囲】

【請求項１】　合金中の炭化物最大粒子径が０．６μｍ以下及びオーステナイト結晶の平均粒子径が２．０μｍ以下であることを特徴とする焼結工具鋼。

【請求項２】　合金成分が重量％でＣを０．８～２．５％、Ｃｒを３～８％、Ｍｏを１～１０％、Ｗを１～２０％、Ｖを１～７％、Ｃｏを１５％以下、Ｓｉを１％以下、Ｍｎを１％以下含有すると同時にＷ当量（２Ｍｏ＋Ｗ）が１５～３０％であり、残部がＦｅと不可避不純物から成る組成を有することを特徴とする請求項１記載の焼結工具鋼。

【請求項３】　焼結工具鋼の構成相として平均粒子径が１～１００ｎｍの酸化物を１種または２種以上、重量％で０．１～１％を含有することを特徴とする請求項１又は２記載の焼結工具鋼。

【請求項４】　重量％でＣを０．８～２．５％、Ｃｒを３～８％、Ｍｏを１～１０％、Ｗを１～２０％、Ｖを１～７％、Ｃｏを１５％以下、Ｓｉを１％以下、Ｍｎを１％以下含有すると同時にＷ当量（２Ｍｏ＋Ｗ）が１５～３０％であり、残部Ｆｅと不可避不純物から成る組成を有する合金を高周波溶解炉にて溶解すると同時にガスアトマイズ法または水アトマイズ法によって急冷凝固粉末を得た後、前記凝固粉末を粒子径で７５μｍ以下に分級してボールミル等により強加工を施し高歪付加ミリング粉末を製造し、ついで前記ミリング粉末を鋼製容器中に充填し４００～６００℃にて真空脱気後、８００～１０００℃で加熱を行うと同時に圧下率７０～９０％での圧延、または押出比４～１０での押出を行って成形焼結することを特徴とする焼結工具鋼の製造方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は超微細粒組織を有する焼結工具鋼およびその製造方法に関し、高強度で耐摩耗性と加工性に優れた、工具、構造部材等として特に極小および極薄部材に好適な高強度超微細粒の焼結工具鋼に関するものである。

【０００２】

【従来の技術】従来よりＳＫＨ５１に代表される高速度工具鋼は切削工具用や金型、更には耐摩耗用部材等として広く用いられてきた。また高速度工具鋼の性能改良には成分組成改良の他に製造技術による改良として、従来の溶解造塊方式に対してアトマイズ粉末を用いたＨＩＰ焼結法いわゆる粉末冶金方式の採用などがある。一方、最近の電子関連分野に代表される半導体の高集積度化、コンパクト化が進み、関連部材として例えば極小径ピン等で直径１００μｍ以下の加工に対応できる高強度の耐摩部材等が求められるようになってきた。しかしながら従来の溶解材より強度と靭性が高い粉末冶金方式による工具鋼、例えば、焼結炭素工具鋼、焼結合金工具鋼さらには焼結高速度工具鋼においても要求される強度、靭性面で満足に対応できないといった問題点がでてきた。

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【０００３】

【発明が解決しようとする課題】高速度工具鋼の耐摩耗性、強度、延性、被研削性の向上に対応すべき要因は金属組織学的に見ると、含有する合金組成とオーステナイト結晶粒子の大きさ及び化合物などとして分散する炭化物や酸化物粒子の大きさ並びにそれらの分散等に強く影響される。一般的に、結晶粒が小さいほど即ち微細なオーステナイト結晶粒子と微細かつ均一に分散した炭化物粒子を含んでいる場合はこれらの性質は改良される。しかしながら従来の粉末冶金法による高速度工具鋼にあってはオーステナイト結晶粒子径は７～１０μｍまた炭化物粒子径は２～４μｍの物を多数含んでおり、これ以上の大幅な性能向上は期待できない。

【０００４】本発明の課題は炭化物含有量の多い工具鋼にあってマルテンサイト組織及び炭化物を従来材に比べて大幅に微細化させることによって高強度で耐摩耗性と加工性に優れた高強度超微細粒の焼結工具鋼を提供することにある。また、かかる焼結工具鋼を製造する方法を提供することである。

【０００５】

【課題を解決するための手段】本発明者等は、オーステナイト結晶粒子径、炭化物粒子径について着目しこれらの粒子径を小さくする方法について研究した結果、急冷凝固アトマイズ粉末の中に晶出した樹枝状晶の間隙に生ずる粗大な炭化物を高歪付加粉末冶金プロセスにより基地中に出来るだけすみやかに固溶させ消滅させる粉末処理法と温間強圧下加工による動的焼結を組み合わせることによって従来材より低温で焼結を可能にした。このような製法により、基地からの析出炭化物粒子が微細となると共に炭化物粒子並びに結晶粒の成長が抑制された結果、超微細化組織を得ることが可能となった。このようにして得られた超微細化組織を有する材料について種々の試験をおこなった。その結果、合金中の炭化物最大粒子径が０．６μｍ以下及びオーステナイト結晶の平均粒子径が２μｍ以下の焼結工具鋼については、従来の工具鋼に比べて最も高強度になるという知見を得た。この知見により、本発明においては、合金中の炭化物最大粒子径が０．６μｍ以下及びオーステナイト結晶の平均粒子径が２．０μｍ以下の焼結工具鋼を提供することにより前記課題を解決した。

【０００６】請求項１の発明の焼結工具鋼の化学成分は、従来の工具鋼即ち炭素工具鋼、合金工具鋼、高速度工具鋼等と同様でも良いが、より好ましくは、合金成分が重量％でＣを０．８～２．５％、Ｃｒを３～８％、Ｍｏを１～１０％、Ｗを１～２０％、Ｖを１～７％、Ｃｏを１５％以下、Ｓｉを１％以下、Ｍｎを１％以下含有すると同時にＷ当量（２Ｍｏ＋Ｗ）が１５～３０％であり、残部がＦｅと不可避不純物から成る組成とした焼結工具鋼とするのが好ましい（請求項２）。

【0007】本発明焼結合金の構成する成分において炭素はＦｅ、Ｍｏ、Ｗ、Ｖ等の複炭化物を構成すると同時に焼入加熱による炭化物の固溶に伴ってマトリックス中に固溶し硬度を高める作用があるが、含有量が０．８％未満の場合十分な硬さが得られないので０．８％以上の含有とした。一方炭素量が２．５％を超えると合金中の炭化物を粗大化させるためこれを上限とした。

【0008】Ｃｒは、主として炭化物を構成するが、焼入によってその全量を基地に固溶し自硬性を与えるとともに耐焼戻し性を補強するため３％以上必要であるが８％を超えると熱間加工性を劣化させまた焼入時の残留オーステナイトが著しく増加するため３～８％とする。

【0009】ＭｏとＷは、共に、炭化物を構成し耐摩耗性を与え、焼入に際して基地に一部固溶して強度と硬さを高めると共に耐熱性を改善する元素として有効でありＭｏ及びＷの含有量としてはいずれも１％以上であってかつＷ当量（２Ｍｏ＋Ｗ）では１５％以上が必要である。一方Ｍｏ１０％、Ｗ２０％を超えかつＷ当量（２Ｍｏ＋Ｗ）で３０％を超えると炭化物量が多くなり靭性を著しく低下させるのでこれを上限とした。

【0010】Ｖは、硬質なＭＣ炭化物として耐摩耗性を高めると共に分散効果でオーステナイト結晶粒の微細化に有効であり、含有量としては１％以上必要であるが７％を超えるとＭＣ炭化物を著しく粗大化させ、被研削性を悪くするため７％以下とした。

【0011】Ｃｏは、ほぼ全量が基地に固溶して焼入の際にＷ、Ｍｏ等の炭化物固溶を促進し高温強度を高めるのに有効であるが１５％を超えるとその添加効果は少なくコスト高となるため１５％以下とした。Ｓｉ、Ｍｎは主に脱酸剤として使用され含有量は１％以下とする。

【0012】SiO_2、CrO_3、Al_2O_3、Y_2O_3等の酸化物はできる限り少ない方がよい。しかし、これらの酸化物は焼入加熱によっても基地に固溶しないことから加熱による結晶粒の成長を抑制するピン止め効果が期待される。そこで、請求項３に記載の発明においては、焼結工具鋼の構成相として平均粒子径が１～１００ｎｍの酸化物を１種または２種以上、重量％で０．１～１％を含有させるようにした。酸化物の大きさが１００ｎｍ以上を超えるかその量が１％を超えると靭性を著しく劣化させるので１００ｎｍを上限とした。

【0013】かかる高強度超微細粒の焼結工具鋼は、次にようにして得られる。即ち請求項４に記載の発明においては、重量％でＣを０．８～２．５％、Ｃｒを３～８％、Ｍｏを１～１０％、Ｗを１～２０％、Ｖを１～７％、Ｃｏを１５％以下、Ｓｉを１％以下、Ｍｎを１％以下含有すると同時にＷ当量（２Ｍｏ＋Ｗ）が１５～３０％であり、残部Ｆｅと不可避不純物から成る組成を有する合金を高周波溶解炉にて溶解すると同時にガスアトマイズ法または水アトマイズ法によって急冷凝固粉末を得た後、前記凝固粉末を粒子径で７５μｍ以下に分級してボールミル等により強加工を施し高歪付加ミリング粉末を製造し、ついで前記ミリング粉末を鋼製容器中に充填し４００～６００℃にて真空脱気後、８００～１０００℃で加熱を行うと同時に圧下率７０～９０％での圧延、または押出比４～１０での押出を行って成形焼結する焼結工具鋼の製造方法を提供することにより、合金中の炭化物最大粒子径が０．６μｍ以下及びオーステナイト結晶の平均粒子径が２μｍ以下の焼結合金を得ることができた。

【0014】超微細粒組織を有する焼結合金の製造方法は、ガスアトマイズ法または水アトマイズ法によって急冷凝固された粉末の中からふるいにより粒子径で７５μｍ以下に分級したものを、撹拌型、遊星型、振動型ボールミル等の高エネルギー型ボールミルによって、５０～２００時間の高歪付加プロセス（メカニカルミリング）を行う。この際に粉末粒子径が大きすぎたり処理時間が短いと粉末中央部にまで加工が行われず成形焼結後に粗大な炭化物が残存するため機械的特性に悪い影響を及ぼす。また処理時間が２００時間を超えても有効なエネルギーを与えることは出来ないので２００時間以下が好ましい。

【0015】また撹拌型、遊星型、振動型ボールミル等の高エネルギー型ボールミルによって、５０～２００時間の高歪付加プロセス（メカニカルミリング）を行う際に、必要に応じてSiO_2、CrO_3、Al_2O_3、Y_2O_3等を加え構成相として平均粒子径が１～１００ｎｍで、重量％で０．１～１％になる酸化物を１種または２種以上含む混合物を使用してもよい。

【0016】次に、粉末の成形焼結には、メカニカル処理粉末を鋼製容器中に４００～６００℃で真空封入したものを８００～１０００℃で加熱を行い、ついで圧下率７０～９０％の熱間圧延を行うか、或いは押出比４～１０の熱間押出を行って成形焼結する。成形焼結温度が８００℃未満では内部割れ等の欠陥が発生することがあり、また１０００℃を超えると炭化物粒子やオーステナイト結晶の粒子が粗大となり機械的特性に悪影響を及ぼす。

【0017】

【実施例】次に本発明の実施例及び試験成績について述べる。

（実施例１）表１に示す本発明例１の成分からなる合金を予めガスアトマイズによって急冷凝固し、この粉末をふるいにより粒子径で７５μｍ以下に分級した粉末をＳＫＤ１１製容器にＳＵＪ２ボールと重量比１４．４：１にてＡｒ雰囲気中にて充填し遊星ボールミル（高エネルギー型ボールミルの１種）にて２００時間高歪付加を行い得られた粉末を鋼製カプセルに充填し、４００℃にて真空脱気後封じた物を、１０００℃で加熱を行うと同時に押出し比９での熱間押出を行って成形焼結し更に伸線と焼鈍を繰り返し直径を０．２ｍｍまで細くしたものを

１２００℃で焼入した後、５６０℃×１時間×３回焼戻し処理を行ったものについて結晶粒度解析、抗折試験、被研削性試験、曲げ疲労試験を行った。

【００１８】結晶粒度解析においてオーステナイト結晶粒及び炭化物粒径は上記焼入処理後試験片の縦断面を５％硝酸アルコール溶液にて腐食し画像解析を行ったものであり、粒子径は等価円直径によって求めたものである。なお、ここで、等価円直径とは粒子断面の面積を円の面積として置き換えた場合の円の直径をいう。抗折試験には直径０．２ｍｍの線材を上記熱処理後、スパン１２．７ｍｍの３点曲げ抗折試験を実施した。また被研削性試験は直径０．２ｍｍの線材を上記熱処理後＃１２００の砥石にて延べ８０００本切断した後の砥石の減量比にて比較したものである。また、曲げ疲労試験は直径０．２ｍｍの線材を上記熱処理後最大応力１４０ｋｇ／ｍｍ^{2}の負荷を与える繰り返し曲げ疲労寿命試験機にて行ったものである。比較例は対応する発明例とほぼ同様の成分とし、従来の熱間静水圧プレス（ＨＩＰ）により、成形焼結したものである（以下同じ）。

【００１９】

【表１】

区分	化学成分　重量% C	Si	Mn	Cr	W	Mo	V	Co	Fe	酸化物 SiO2	成形焼結条件 温度(℃)	焼結法	圧下率%	押出比	炭化物粒子 平均径 μm	最大径 μm	オーステナイト結晶粒平均径μm	試験結果 抗折力 GPa	被研削性指数	曲げ疲労寿命
本発明例1	1.37	0.31	0.29	4.1	6	5.1	2.9	8	残	-	1000	押出	-	9	0.31	0.49	1.5	4.9	180	4×10^7回以上
本発明例2	2.10	0.34	0.33	4.1	8.2	3.9	5.9	6.4	残	-	1000	押出	-	5	0.3	0.5	1.3	4.8	200	2×10^7回
本発明例3	0.93	0.24	0.24	3.9	6.4	5.1	2	-	残	-	800	圧延	85	-	0.27	0.45	1.3	5.2	200	4×10^7回以上
本発明例4	0.92	0.24	0.24	3.9	6.4	5.1	3	-	残	0.15	800	圧延	85	-	0.27	0.45	0.9	5.4	210	4×10^7回以上
比較例1	1.29	0.3	0.29	4	6.1	5.1	2.9	8.1	残	-	1150	HIP	-	-	1.1	3.4	3.6	3.3	100	2×10^6
比較例2	2.12	0.27	0.32	4.21	8.1	4.1	6	6.3	残	-	1150	HIP	-	-	1.0	3.4	5.4	3.2	120	7×10^6
比較例3	0.92	0.24	0.24	3.9	6.4	5.1	2	-	残	-	1150	HIP	-	-	1.05	3.2	3.7	3.4	110	6×10^6

(注)原料粉の形態　：　本発明例１～４:７５μｍ以下の急冷凝固粉末をメカニカルミリング
　　　　　　　　　：　比較例１～３:急冷凝固粉末

【００２０】その結果、本発明例１は比較例１の従来粉末材に比べ抗折力においては５０％程度向上し、被研削性においては８０％程度向上、曲げ疲労寿命においては２０倍以上向上した。図１は本発明の焼結工具鋼の実施例（発明例１）の結晶粒及び、従来の比較例１の結晶粒を示す電子顕微鏡写真である。図１で示すように、オーステナイト結晶粒、オーステナイト結晶粒界、炭化物は比較例１のものに較べ本発明例１のものが格段に小さく、本発明の焼結工具鋼が従来のものに比して超微細粒の焼結工具鋼であることがわかる。

【００２１】（実施例２）表１に示す本発明例２の成分からなる合金を予めガスアトマイズによって急冷凝固し、この粉末をふるいにより粒子径で７５μｍ以下に分級した粉末をＳＫＤ１１製容器にＳＵＪ２ボールと重量比１４．４：１にてＡｒ雰囲気中にて充填し、遊星ボールミル（高エネルギー型ボールミルの１種）にて２００

時間高歪付加を行い、得られた粉末を鋼製カプセルに充填し、400℃にて真空脱気後封じた物を、1000℃で加熱を行うと同時に押出し比5での熱間押出を行って成形焼結し更に伸線と焼鈍を繰り返し、直径を0．2mmまで細くしたものを1200℃で焼入した後、560℃×1時間×3回焼戻し処理を行ったものについて実施例1記載の方法にて結晶粒度解析、抗折試験、被研削性試験、曲げ疲労試験を行った。

【0022】その結果、前述したと同様に、本発明例2は比較例2の従来粉末材に比べ抗折力においては50％程度向上し、被研削性においては80％程度向上、曲げ疲労寿命においては28倍以上向上した。

【0023】（実施例3）表1に示す本発明例3の成分からなる合金を予め水アトマイズによって急冷凝固し、この粉末をふるいにより粒子径で75μm以下に分級した粉末をSKD11製容器にSUJ2ボールと重量比14．4：1にてAr雰囲気中にて充填し、遊星ボールミル（高エネルギー型ボールミルの1種）にて100時間高歪付加を行い、得られた粉末を鋼製カプセルに充填し400℃にて真空脱気後封じた物を、800℃で加熱を行うと同時に累積圧下率85％での圧延を行った。更に伸線と焼鈍を繰り返し、直径を0．2mmまで細くしたものを1200℃で焼入した後、560℃×1時間×3回焼戻し処理を行ったものについて実施例1記載の方法にて結晶粒度解析、抗折試験、被研削性試験、曲げ疲労試験を行った。

【0024】その結果、前述したと同様に、本発明例3は比較例3の従来粉末材に比べ抗折力においては50％程度向上し、被研削性においては80％程度向上、曲げ疲労寿命においては6倍以上向上した。

【0025】（実施例4）本発明例4は、表1に示す本発明例3の成分からなる合金を予め水アトマイズによって急冷凝固し、この粉末をふるいにより粒子径で75μm以下に分級した粉末と市販の1μmのSiO_2酸化物を加えてSKD11製容器にSUJ2ボールと重量比14．4：1にてAr雰囲気中にて充填し、遊星ボールミル（高エネルギー型ボールミルの1種）にて100時間高歪付加を行い、得られた粉末を鋼製カプセルに充填し400℃にて真空脱気後封じた物を、800℃で加熱を行うと同時に累積圧下率85％での圧延を行った。更に伸線と焼鈍を繰り返し、直径を0．2mmまで細くしたものを1200℃で焼入した後、560℃×1時間×3回焼戻し処理を行ったものについて実施例1記載の方法にて結晶粒度解析、抗折試験、被研削性試験、曲げ疲労試験を行った。

【0026】本発明例4は比較例3比べ抗折力においては50％程度向上し、被研削性においても90％程度向上、曲げ疲労寿命においては6倍以上向上した。また、本発明例3よりオーステナイト結晶粒平均径が小さく、また、抗折力、被研削性も高めであり、酸化物を加えた効果が現れている。

【0027】

【発明の効果】以上述べたように、本発明では耐摩耗性を有する工具鋼と同様な成分を焼結により、炭化物最大粒子径が0．6μm以下及びオーステナイト結晶の平均粒子径が2μm以下の超微細粒組織とすることによって高強度の焼結工具鋼が得られた。かかる焼結工具鋼は、特に200μm以下の極小、極薄工具、金型および構造部材に好適な耐摩耗高強度素材として使用できる。

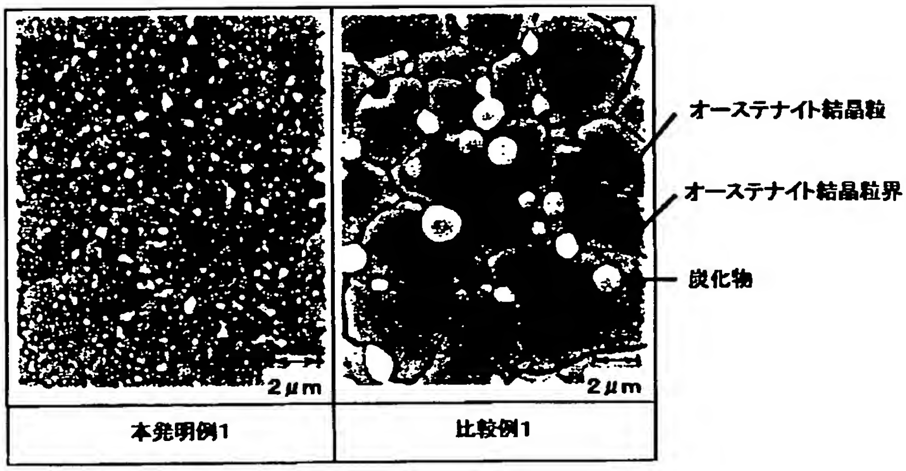
【0028】合金成分を重量％でCを0．8〜2．5％、Crを3〜8％、Moを1〜10％、Wを1〜20％、Vを1〜7％、Coを15％以下、Siを1％以下、Mnを1％以下含有すると同時にW当量（2Mo＋W）が15〜30％であり、残部がFeと不可避不純物から成る組成とし、炭化物の微細化を図るとともに工具鋼としての性能を確保した。また、酸化物による結晶粒の成長を抑制するピン止め効果を利用して超微細粒組織を容易に得られるようにした。

【0029】また、高周波溶解炉、ガスアトマイズ法または水アトマイズ法、ボールミル、真空脱気、熱間圧延、又は熱間押出等の従来の工法を組み合わせて容易にかかる高強度超微細粒の焼結工具鋼の製造方法を提供するものであり、産業上有益なものとなった。

【図面の簡単な説明】

【図1】本発明の焼結工具鋼の実施例（発明例1）の結晶粒及び、従来の比較例1の結晶粒を示す電子顕微鏡写真である。

【図1】



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CLAIMS

[Claim(s)]
[Claim 1] Sintered tool steel with which the carbide maximum particle diameter in an alloy is characterized by the mean particle diameter of 0.6 micrometers or less and an austenite crystal being 2.0 micrometers or less.
[Claim 2] An alloy content for Cr Mo 3 to 8% 0.8 to 2.5% by weight % 1 - 10%, [C] Sintered tool steel according to claim 1 characterized by having the presentation to which W Eq (2 Mo+W) is 15 - 30% while Co is contained for V and Mn is contained for Si 1% or less 1% or less 15% or less 1 to 7% 1 to 20%, and the remainder changes W from Fe and an unescapable impurity.
[Claim 3] Sintered tool steel according to claim 1 or 2 characterized by containing 0.1 - 1% for the oxide whose mean particle diameter is 1-100nm as a configuration phase of sintered tool steel by one sort or two sorts or more, and weight %.
[Claim 4] For Cr Mo 3 to 8% 0.8 to 2.5% by weight % 1 - 10%, [C] For Co Si 15% or less 1 to 7% 1 to 20% 1% or less, [W] [V] While Mn is contained 1% or less, W Eq (2 Mo+W) is 15 - 30%. After obtaining the end of rapidly solidified powder by the gas atomizing method or the water atomizing method at the same time it dissolves the alloy which has the presentation which consists of Remainder Fe and an unescapable impurity with a RF fusion furnace, Classify said coagulation powder in 75 micrometers or less with particle diameter, perform strong processing with a ball mill etc., and high distorted addition milling powder is manufactured. Subsequently, the manufacture approach of the sintered tool steel characterized by performing extrusion in rolling at 70 - 90% of rolling reduction, or extrusion ratios 4-10, and carrying out shaping sintering at the same time it is filled up with said milling powder into a steel container, and performs the vacuum deairing back at 400-600 degrees C and heats at 800-1000 degrees C.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] as a tool, a structural member, etc. this invention excelled [structural member] in abrasion resistance and workability with high intensity about the sintered tool steel which overly has a detailed grain organization, and its manufacture approach -- the suitable high intensity especially for the minimum and an ultra-thin member -- it is overly related with the sintered tool steel of a detailed grain.
[0002]
[Description of the Prior Art] The high speed tool steel conventionally represented by SKH51 has been widely used as the metallurgy mold for cutting tools, a member for antifriction, etc. Moreover, as amelioration by the manufacturing technology, engine-performance amelioration of high speed tool steel has adoption of the HIP sintering process ******** powder metallurgy method using atomization powder etc. to the conventional dissolution ingot making method besides component presentation amelioration. On the other hand, the high integration of the semi-conductor represented by the latest electronic related field and miniaturization progress, and the abrasion-resistant member of high intensity which can respond to processing with a diameter of 100 micrometers or less for example, by the diameter pin of the minimum etc. as a related member has come to be called for. However, the trouble demanded also in sintering high speed tool steel that it could not respond to satisfaction in respect of reinforcement and toughness appeared in the tool steel by the powder metallurgy method with high reinforcement and toughness, for example, sintering carbon tool steel, and a sintered alloy tool steel pan from the conventional dissolution material.
[0003]
[Problem(s) to be Solved by the Invention] If the factor which should correspond to improvement in the abrasion resistance of high speed tool steel, reinforcement, ductility, and grindability is seen in metallography, it will be strongly influenced in those distributions etc. by the magnitude list of carbide or an oxide particle distributed as magnitude, a compound, etc. of the alloy presentation to contain and an austenite crystal grain child. Generally, these properties are improved, detailed, when the carbide particle distributed to homogeneity is included, and when [, so that crystal grain is small, namely / a detailed austenite crystal grain child and]. However, if it is in the high speed tool steel by the conventional powder-metallurgy processing, as for austenite crystal particle diameter, carbide particle diameter contains 7-10 micrometers of many 2-4-micrometer objects again, and the large improvement in the engine performance beyond this cannot be expected.
[0004] the high intensity which was excellent in abrasion resistance and workability with high intensity by the technical problem of this invention being in tool steel with many carbide contents, and making martensitic structure and carbide make it detailed sharply compared with the conventional material -- it is overly in offering the sintered tool steel of a detailed grain. Moreover, it is offering the approach of manufacturing this sintered tool steel.
[0005]
[Means for Solving the Problem] The result studied about the approach of this invention person etc.

paying his attention about austenite crystal particle diameter and carbide particle diameter, and making these particle diameter small, The big and rough carbide produced in the gap of the dendrite crystallized in rapid solidification atomization powder according to a high distorted addition powder metallurgy process Sintering was made more possible than the conventional material at low temperature by combining dynamic sintering by the powder approach which makes it dissolve to radical underground as much as possible whether you are Sumiya, and extinguishes it, and processing under the pressure between **. While the deposit carbide particle from a base became detailed, as a result of grain growth's being controlled by the carbide particle list by such process, it became possible overly to obtain a detailed-ized organization. Thus, various trials were performed about the obtained ingredient which overly has a detailed-ized organization. Consequently, the carbide maximum particle diameter in an alloy acquired the knowledge that the mean particle diameter of 0.6 micrometers or less and an austenite crystal became high intensity most about sintered tool steel 2 micrometers or less compared with the conventional tool steel. By this knowledge, in this invention, the carbide maximum particle diameter in an alloy solved said technical problem, when the mean particle diameter of 0.6 micrometers or less and an austenite crystal offered sintered tool steel 2.0 micrometers or less.
[0006] Although the chemical entity of the sintered tool steel of invention of claim 1 may be the same as that of the conventional tool steel, i.e., carbon tool steel, alloy tool steel, high speed tool steel, etc., more preferably An alloy content for Cr Mo 3 to 8% 0.8 to 2.5% by weight % 1 - 10%, [C] It is desirable to consider as the sintered tool steel which W Eq (2 Mo+W) is 15 - 30% while Co is contained for V and Mn is contained for Si 1% or less 1% or less 15% or less 1 to 7% 1 to 20%, and considered W as the presentation from which the remainder consists of Fe and an unescapable impurity (claim 2).
[0007] While carbon constituted double carbide, such as Fe, Mo, W, and V, in the component which this invention sintered alloy constitutes, there was an operation which dissolves in a matrix with dissolution of the carbide by hardening heating, and raises a degree of hardness, but since sufficient hardness was not obtained when a content was less than 0.8%, it considered as 0.8% or more of content. This was made into the upper limit in order to make the carbide in an alloy make it big and rough on the other hand, when a carbon content exceeds 2.5%.
[0008] Since hot-working nature will be degraded and the retained austenite at the time of hardening will increase remarkably again if it exceeds 8%, although it is required 3% or more in order to reinforce annealing-proof nature, while dissolving the whole quantity on a base and giving self-hardening with hardening, although carbide is mainly constituted, Cr may be 3 - 8%.
[0009] It is effective as an element which improves thermal resistance, and they are all 1% or more as a content of Mo and W, and are required of W Eq (2 Mo+W) while both Mo and W constitute carbide, give abrasion resistance, dissolve in part on a base on the occasion of hardening and raise reinforcement and hardness. [15% or more of] Since the amount of carbide increases and toughness was remarkably reduced when Mo10% and W20% were exceeded on the other hand and it exceeded 30% by W Eq (2 Mo+W), this was made into the upper limit.
[0010] Although V is effective in detailed-izing of austenite crystal grain and required of a dispersion effect 1% or more as a content while it raises abrasion resistance as hard MC carbide, if it exceeded 7%, in order that it might make MC carbide make it big and rough remarkably and might worsen grindability, it could be 7% or less.
[0011] Mostly, the whole quantity dissolved on the base, and although Co was effective in promoting carbide dissolution of W, Mo, etc. and raising high temperature strength in the case of hardening, when it exceeded 15%, since the addition effectiveness served as cost quantity few, it made it 15% or less. Si and Mn are mainly used as a deoxidizer and a content is made into 1% or less.
[0012] The fewer possible one of the oxide of SiO2, CrO3, aluminum 2O3, and Y2O3 grade is good. However, since these oxides do not dissolve on a base with hardening heating, the pinning effectiveness which controls the grain growth by heating is expected. Then, it was made to make 0.1 - 1% contain the oxide whose mean particle diameter is 1-100nm as a configuration phase of sintered tool steel by one sort or two sorts or more, and weight % in invention according to claim 3. Since toughness was remarkably degraded when the magnitude of an oxide exceeded 100nm or more or the amount exceeded

1%, 100nm was made into the upper limit.
[0013] this high intensity -- sintered tool steel of a detailed grain is made like next, and is overly obtained. In invention according to claim 4 C by weight % Namely, 0.8 - 2.5%, For W V 1 to 20% 1 to 10% 3 to 8% 1 - 7%, [Cr] [Mo] While Co is contained and Mn is contained for Si 1% or less 1% or less 15% or less, W Eq (2 Mo+W) is 15 - 30%. After obtaining the end of rapidly solidified powder by the gas atomizing method or the water atomizing method at the same time it dissolves the alloy which has the presentation which consists of Remainder Fe and an unescapable impurity with a RF fusion furnace, Classify said coagulation powder in 75 micrometers or less with particle diameter, perform strong processing with a ball mill etc., and high distorted addition milling powder is manufactured. It is filled up with said milling powder into a steel container. At 400-600 degrees C Subsequently, after a vacuum deairing, By offering rolling at 70 - 90% of rolling reduction, or the manufacture approach of the sintered tool steel which performs extrusion in extrusion ratios 4-10, and carries out shaping sintering at the same time it heats at 800-1000 degrees C The mean particle diameter of 0.6 micrometers or less and an austenite crystal was able to obtain [the carbide maximum particle diameter in an alloy] the sintered alloy 2 micrometers or less.
[0014] The manufacture approach of a sintered alloy of overly having a detailed grain organization performs the high distorted addition process (mechanical milling) of 50 - 200 hours for what was classified in 75 micrometers or less with particle diameter with the screen out of the powder by which rapid solidification was carried out by the gas atomizing method or the water atomizing method with high energy mold ball mills, such as a churning mold, a planet mold, and an oscillatory type ball mill. In this case, since powder particle diameter is too large, or processing is not performed even in the powder center section but big and rough carbide remains after shaping sintering if the processing time is short, it has bad effect on a mechanical property. Moreover, since effective energy cannot be given even if the processing time exceeds 200 hours, 200 or less hours is desirable.
[0015] Moreover, one sort or the mixture included two or more sorts may be used for the oxide from which SiO2, CrO3, aluminum 2O3, and Y2O3 grade are added if needed, and mean particle diameter becomes 0.1 - 1% by 1-100nm as a configuration phase at weight % with high energy mold ball mills, such as a churning mold, a planet mold, and an oscillatory type ball mill, in case the high distorted addition process (mechanical milling) of 50 - 200 hours is performed.
[0016] Next, for powdered shaping sintering, what carried out vacuum enclosure of the mechanical processing powder at 400-600 degrees C into the steel container is heated at 800-1000 degrees C, subsequently hot rolling of 70 - 90% of rolling reduction is performed, or hot extrusion of extrusion ratios 4-10 is performed, and shaping sintering is carried out. At less than 800 degrees C, if defects, such as an inner crack, may occur and shaping sintering temperature exceeds 1000 degrees C, it will become big and rough [a carbide particle or the particle of an austenite crystal], and will have a bad influence on a mechanical property.
[0017]
[Example] Next, the example and trial results of this invention are described.
The rapid solidification of the alloy which consists of a component of the example 1 of this invention shown in Table 1 is beforehand carried out by gas atomization. (Example 1) This powder with a screen A steel capsule is filled up with the powder which the powder which classified in 75 micrometers or less with particle diameter is filled [powder] up into the container made from SKD11 with SUJ2 ball and the weight ratio 14.4:1 in Ar ambient atmosphere, and may have had quantity distorted addition performed for 200 hours with a planet ball mill (one sort of a high energy mold ball mill). After tempering what extruded the object stopped after the vacuum deairing at 400 degrees C while heating at 1000 degrees C, performed hot extrusion in a ratio 9, carried out shaping sintering, repeated a wire drawing and annealing further and made the diameter thin to 0.2mm at 1200 degrees C, Grain size number analysis, the transverse test, the grindability trial, and the bending fatigue test were performed about what performed tempering processing 560 degree-Cx 1-hour x 3 times.
[0018] In grain size number analysis, austenite crystal grain and carbide particle size corrode the longitudinal section of the above-mentioned test piece after quenching treatment with a nitric-acid

alcoholic solution 5%, image analysis is performed, and it asks for particle diameter with an equivalence circle diameter. In addition, an equivalence circle diameter means the diameter of circle at the time of replacing the area of a particle cross section as an area of a circle here. For the transverse test, the span 12.7mm three-point bending transverse test was carried out for the wire rod with a diameter of 0.2mm after the above-mentioned heat treatment. Moreover, the loss-in-quantity ratio of the grinding stone after spreading a wire rod with a diameter of 0.2mm with the grinding stone of #1200 after the above-mentioned heat treatment and cutting it 8000 compares a grindability trial. Moreover, the repeat bending fatigue life testing machine which gives the load of 2 for a wire rod with a diameter of 0.2mm the 140kg [/mm] above-mentioned after [heat treatment] maximum stress performs a bending fatigue test. The example of a comparison is used as the almost same component as the corresponding example of invention, and carries out shaping sintering by the conventional hot isostatic press (HIP) (it is below the same).
[0019]
[Table 1]

区分	化学成分 重量%										成形焼結条件				炭化物粒子		オーステナイト	試験結果		
	C	Si	Mn	Cr	W	Mo	V	Co	Fe	酸化物 SiO2	温度 (℃)	焼結法	圧下率%	押出比	平均径 μm	最大径 μm	結晶粒平均径μm	抗折力 GPa	被研削性指数	曲げ疲労寿命
本発明例1	1.27	0.31	0.29	4.1	6	5.1	2.9	8	残	-	1000	押出	-	9	0.31	0.49	1.5	4.9	180	4×10^7回以上
本発明例2	2.10	0.34	0.33	4.1	8.2	3.9	5.9	6.4	残	-	1000	押出	-	5	0.3	0.5	1.3	4.8	200	2×10^7回
本発明例3	0.92	0.24	0.24	3.9	6.4	5.1	2	-	残	-	800	圧延	85	-	0.27	0.45	1.8	5.2	200	4×10^7回以上
本発明例4	0.92	0.24	0.24	3.9	6.4	5.1	2	-	残	0.15	800	圧延	85	-	0.27	0.45	0.9	5.4	210	4×10^7回以上
比較例1	1.29	0.3	0.29	4	6.1	5.1	2.9	8.1	残	-	1150	HIP	-	-	1.1	3.4	6.6	3.3	100	2×10^6
比較例2	2.12	0.27	0.32	4.21	8.1	4.1	6	6.3	残	-	1150	HIP	-	-	1.0	3.4	5.4	3.2	120	7×10^6
比較例3	0.92	0.24	0.24	3.9	6.4	5.1	2	-	残	-	1150	HIP	-	-	1.05	3.2	8.7	3.4	110	6×10^6

(注)原料粉の形態 ： 本発明例1～4:75μm以下の急冷凝固粉末をメカニカルミリング
： 比較例1～3:急冷凝固粉末

[0020] Consequently, the example 1 of this invention improved about 50% in anti-**** compared with the conventional powder material of the example 1 of a comparison, and improved by 20 or more times in improvement and a bending fatigue life in grindability about 80%. Drawing 1 is an electron microscope photograph in which the crystal grain of the example (example 1 of invention) of the sintered tool steel of this invention and the crystal grain of the conventional example 1 of a comparison are shown. as drawing 1 shows, austenite crystal grain, the austenite grain boundary, and carbide have the alike and small thing of the example 1 of this invention compared with the thing of the example 1 of a comparison, and it turns out that the sintered tool steel of this invention is overly the sintered tool steel of a detailed grain as compared with the conventional thing.
[0021] The rapid solidification of the alloy which consists of a component of the example 2 of this invention shown in Table 1 is beforehand carried out by gas atomization. (Example 2) The powder which classified this powder in 75 micrometers or less with particle diameter with the screen is filled up

into the container made from SKD11 with SUJ2 ball and the weight ratio 14.4:1 in Ar ambient atmosphere. A planet ball mill (one sort of a high energy mold ball mill) performs quantity distorted addition for 200 hours. The object which filled up the steel capsule with the obtained powder and was stopped after the vacuum deairing at 400 degrees C Extrude at the same time it heats at 1000 degrees C, perform hot extrusion in a ratio 5, carry out shaping sintering, and a wire drawing and annealing are repeated further. After tempering what made the diameter thin to 0.2mm at 1200 degrees C, grain size number analysis, the transverse test, the grindability trial, and the bending fatigue test were performed by the approach of example 1 publication about what performed tempering processing 560 degree-Cx 1-hour x 3 times.

[0022] Consequently, similarly, the example 2 of this invention improved about 50% in anti-**** compared with the conventional powder material of the example 2 of a comparison, and improved by 28 or more times in improvement and a bending fatigue life in grindability about 80% with having mentioned above.

[0023] The rapid solidification of the alloy which consists of a component of the example 3 of this invention shown in Table 1 is beforehand carried out by water atomization. (Example 3) The powder which classified this powder in 75 micrometers or less with particle diameter with the screen is filled up into the container made from SKD11 with SUJ2 ball and the weight ratio 14.4:1 in Ar ambient atmosphere. While heating the object which performed quantity distorted addition for 100 hours with the planet ball mill (one sort of a high energy mold ball mill), filled up the steel capsule with the obtained powder, and was stopped after the vacuum deairing at 400 degrees C at 800 degrees C, rolling at 85% of accumulation rolling reduction was performed. Furthermore, a wire drawing and annealing were repeated, and after tempering what made the diameter thin to 0.2mm at 1200 degrees C, grain size number analysis, the transverse test, the grindability trial, and the bending fatigue test were performed by the approach of example 1 publication about what performed tempering processing 560 degree-Cx 1-hour x 3 times.

[0024] Consequently, similarly, the example 3 of this invention improved about 50% in anti-**** compared with the conventional powder material of the example 3 of a comparison, and improved by 6 or more times in improvement and a bending fatigue life in grindability about 80% with having mentioned above.

[0025] The example 4 of this invention carries out the rapid solidification of the alloy which consists of a component of the example 3 of this invention shown in Table 1 by water atomization beforehand. (Example 4) Add the powder which classified this powder in 75 micrometers or less with particle diameter with the screen, and a 1-micrometer commercial SiO dioxide, and the container made from SKD11 is filled up with SUJ2 ball and the weight ratio 14.4:1 in Ar ambient atmosphere. While heating the object which performed quantity distorted addition for 100 hours with the planet ball mill (one sort of a high energy mold ball mill), filled up the steel capsule with the obtained powder, and was stopped after the vacuum deairing at 400 degrees C at 800 degrees C, rolling at 85% of accumulation rolling reduction was performed. Furthermore, a wire drawing and annealing were repeated, and after tempering what made the diameter thin to 0.2mm at 1200 degrees C, grain size number analysis, the transverse test, the grindability trial, and the bending fatigue test were performed by the approach of example 1 publication about what performed tempering processing 560 degree-Cx 1-hour x 3 times.

[0026] The example 4 of this invention was compared example of comparison 3, improved about 50% in anti-****, and improved by 6 or more times in improvement and a bending fatigue life also in grindability about 90%. Moreover, an austenite crystal grain pitch diameter is small, and anti-**** and grindability also have it, and the effectiveness which added the oxide has shown up. [higher than the example 3 of this invention]

[0027]

[Effect of the Invention] As stated above, in this invention, in the same component as the tool steel which has abrasion resistance, the mean particle diameter of 0.6 micrometers or less and an austenite crystal was obtained for the carbide maximum particle diameter by sintering, and the sintered tool steel of high intensity was obtained 2 micrometers or less by overly considering as a detailed grain

organization. This sintered tool steel can be especially used as a suitable antifriction high intensity material for the minimum, an ultra-thin tool, metal mold, and a structural member 200 micrometers or less.

[0028] For Cr Mo 3 to 8% 0.8 to 2.5% by weight % 1 - 10%, [an alloy content] [C] While Co is contained for V and Mn is contained for Si 1% or less 1% or less 15% or less 1 to 7% 1 to 20%, W Eq (2 Mo+W) is 15 - 30%, W was considered as the presentation to which the remainder changes from Fe and an unescapable impurity, and while attaining detailed-ization of carbide, the engine performance as tool steel was secured. Moreover, it enabled it overly to obtain a detailed grain organization easily using the pinning effectiveness which controls the grain growth by the oxide.

[0029] moreover, the conventional methods of construction, such as a high frequency fusion furnace, the gas atomizing method or the water atomizing method, a ball mill, a vacuum deairing, hot rolling, or hot extrusion, -- combining -- easy -- this high intensity -- the manufacture approach of the sintered tool steel of a detailed grain is overly offered, and it became useful on industry.

[Translation done.]